

Observation of W Decay in 500 GeV p+p Collisions in the PHENIX Experiment at RHIC

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on behalf of the PHENIX Collaboration

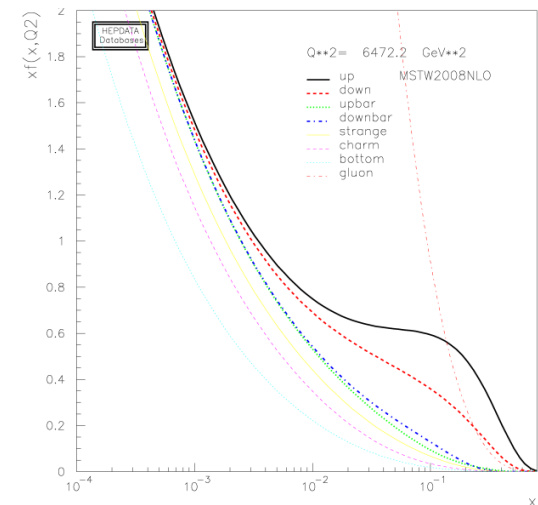
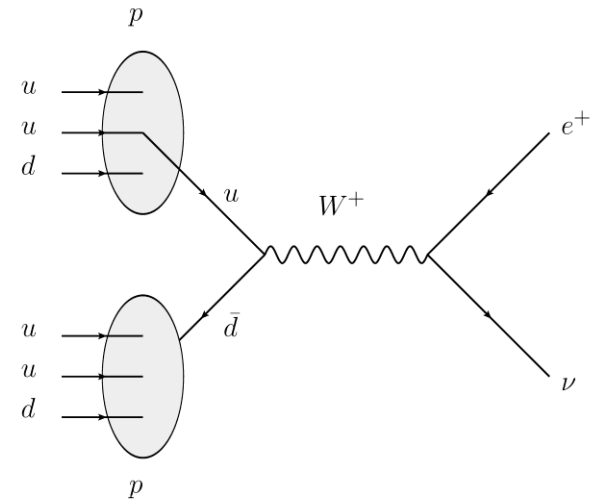


W^\pm at RHIC

- First look at RHIC and PHENIX performance at 500 GeV in one month run in 2009
- First observation in p+p collisions
- First W 's produced with polarized beams
- W 's at RHIC used to access polarized PDF's

What can W decays at RHIC tell us?

- The W^\pm probes the quark distribution in pp
 - Different PDF sampled than in $\bar{p}p$
- Access to polarized PDF's through
 - Cross section
 - W^+/W^- ratio
 - Longitudinal spin asymmetry

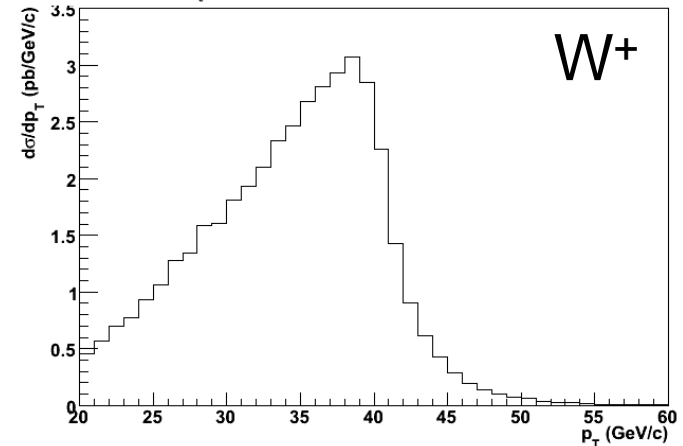


Cross section predictions

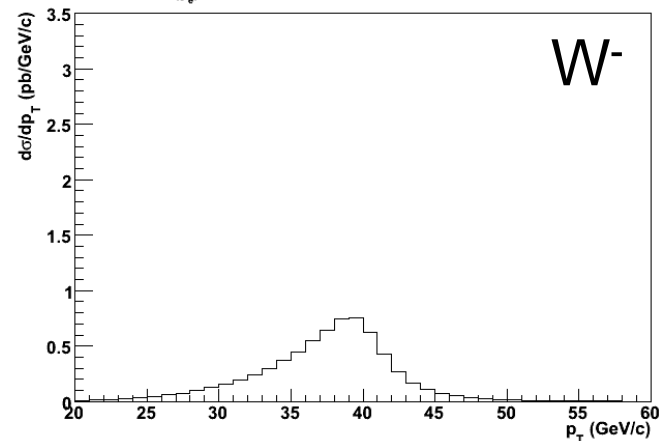
- LO, NLO, and NNLO calculations exist
- Soft gluon resummation important for central region
- RHICBOS Monte Carlo includes spin dependent PDF's

RHICBOS due to Nadolsky and Yuan, Nucl.Phys.B666:31-55,2003

W^+ CTEQ5M ($\sigma_{|y_s|<0.35} = 20.94 \pm 0.14 \text{ pb}$)



W^- CTEQ5M ($\sigma_{|y_s|<0.35} = 3.38 \pm 0.06 \text{ pb}$)



Longitudinal spin asymmetry A_L

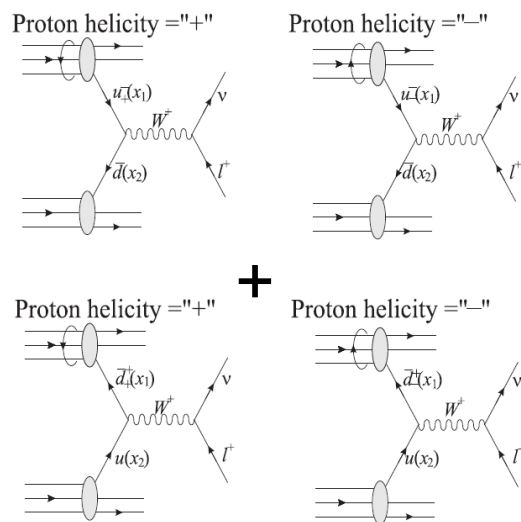
Parity violating longitudinal spin asymmetry can be used to access polarized PDF's by measuring

$$A_L^W = \frac{1}{P} \times \frac{N^+(W) - N^-(W)}{N^+(W) + N^-(W)}$$

- $N^+(W)$ = right handed production of W
- $N^-(W)$ = left handed production of W
- Polarization

Interpreting A_L

A_L in forward/backward rapidity region for W^- has a simple interpretation; in central rapidity it is not so simple but contributes to global fits
Example at LO ignoring other quark contributions:

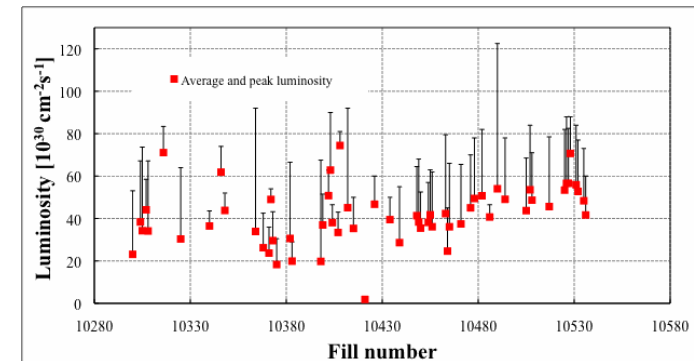
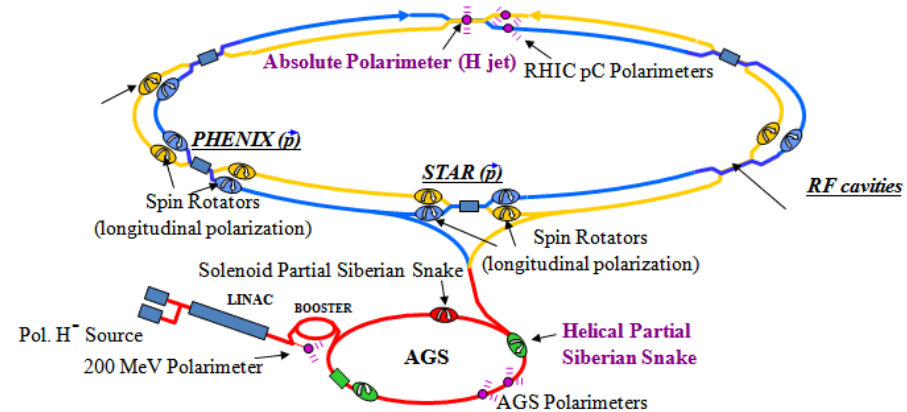


$$= A_L^{W^+} = - \frac{\Delta u(x_1) \bar{d}(x_2) - \Delta \bar{d}(x_1) u(x_2)}{u(x_1) \bar{d}(x_2) + \bar{d}(x_1) u(x_2)}$$

Bunce et al., Ann.Rev.Nucl.Part.Sci.50:525-575,2000 (up to sign convention)

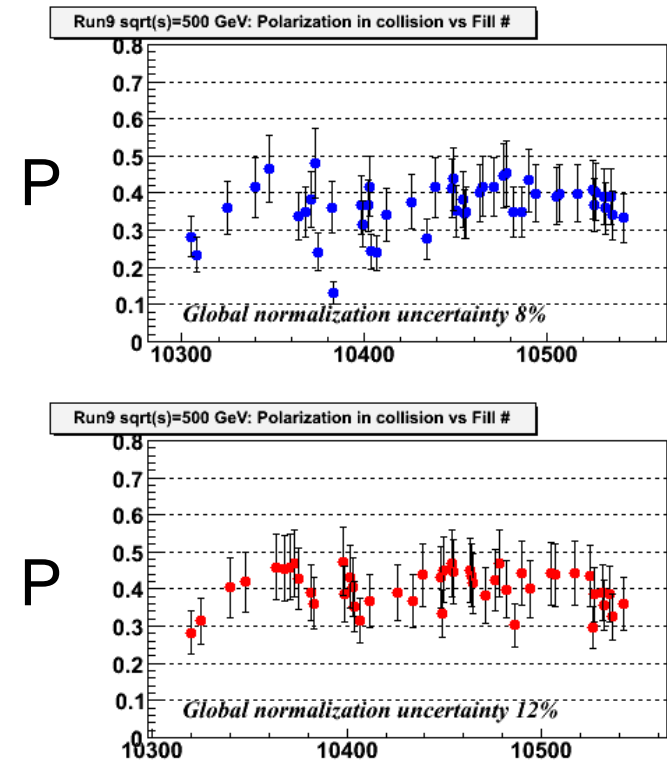
RHIC

- Longitudinally polarized collisions at PHENIX and STAR
- Up to 111 bunch crossings with varied spin orientations for control of systematic errors
- Luminosity typically $\sim 4 \times 10^{31} \text{ cm}^{-2} \text{ sec}^{-1}$



Polarization

- Measured with two polarimeters
 - CNI polarimeter measurements available during run
 - H jet polarimeter provides absolute polarization
 - Measured residual polarization in real time after rotation at PHENIX

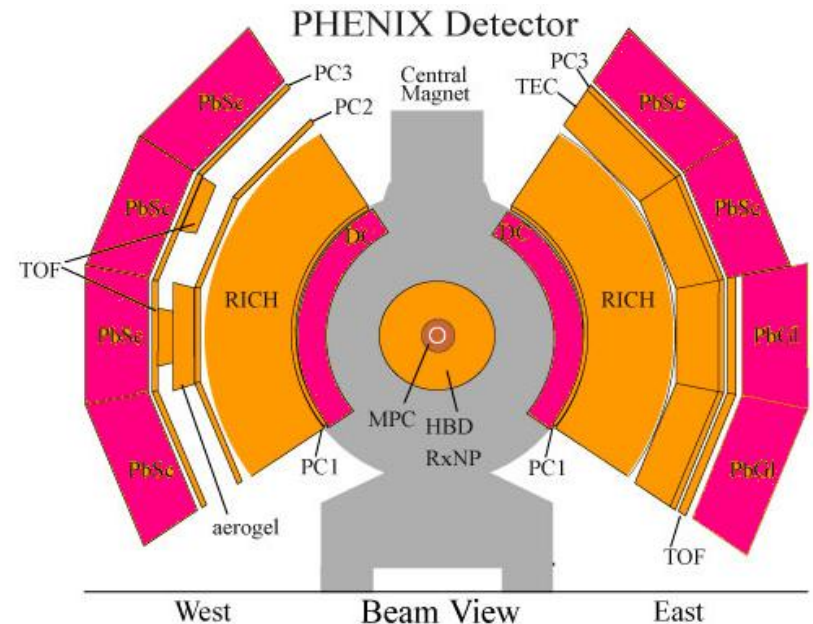


Polarization measured by CNI polarimeters fill-by-fill

PHENIX

Central arm spectrometer

- $|\eta| < 0.35$
- EM calorimeter ($\Delta\phi \times \Delta\eta \sim 0.01 \times 0.01$)
- trigger fully efficient above ~ 12 GeV

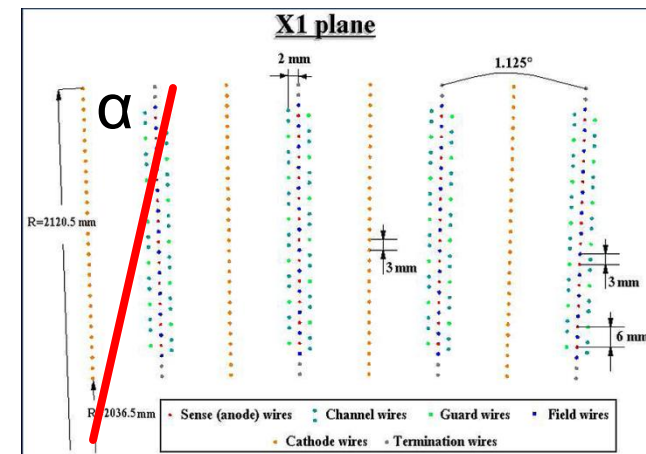
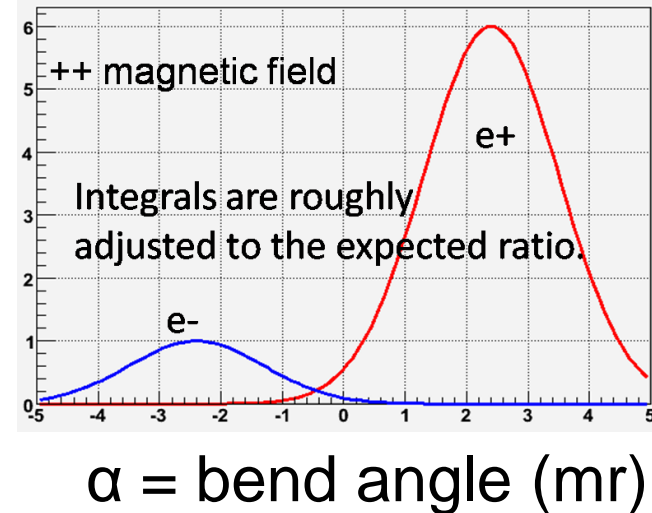


Run 9 500 GeV pp data

- First 500 GeV in RHIC Run 9: March 17-April 13, 2009
- Machine development in parallel with physics running to increase luminosity, polarization, reduce backgrounds
- Detector challenged by high rates, sometimes high backgrounds
- Forward muon arms running only with prototype trigger electronics, RPC's, and shielding (no forward muon physics reported)

Event selection

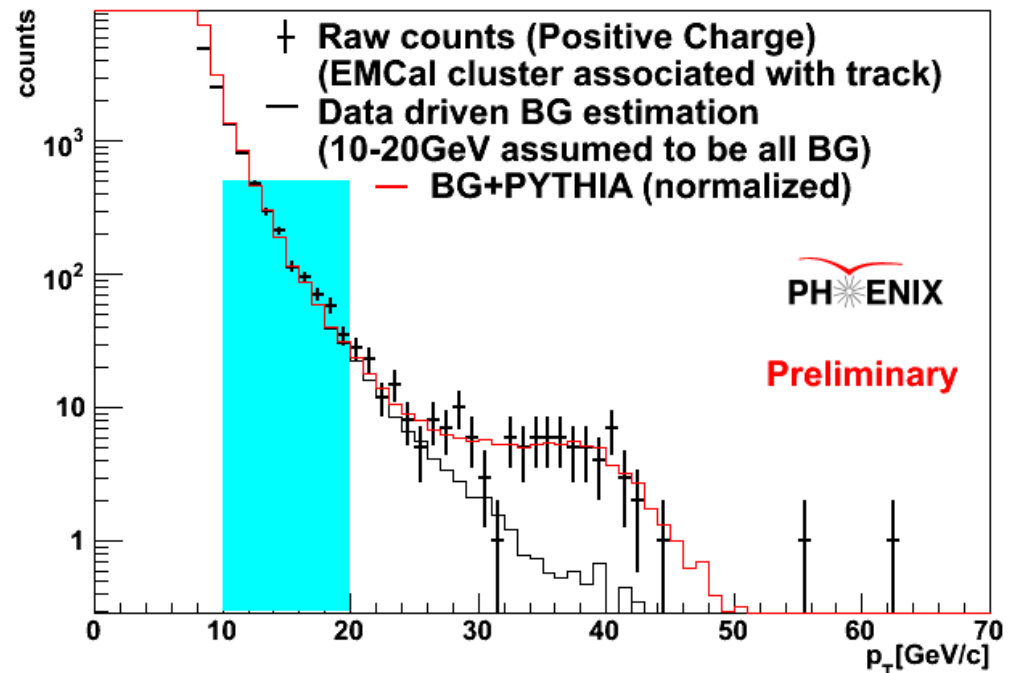
- ± 30 cm vertex cut
- High energy EM Calorimeter clusters matched to charged track
- Loose timing cut eliminates cosmic rays
- Momentum resolution allows only loose E/p cut



Drift Chamber cell

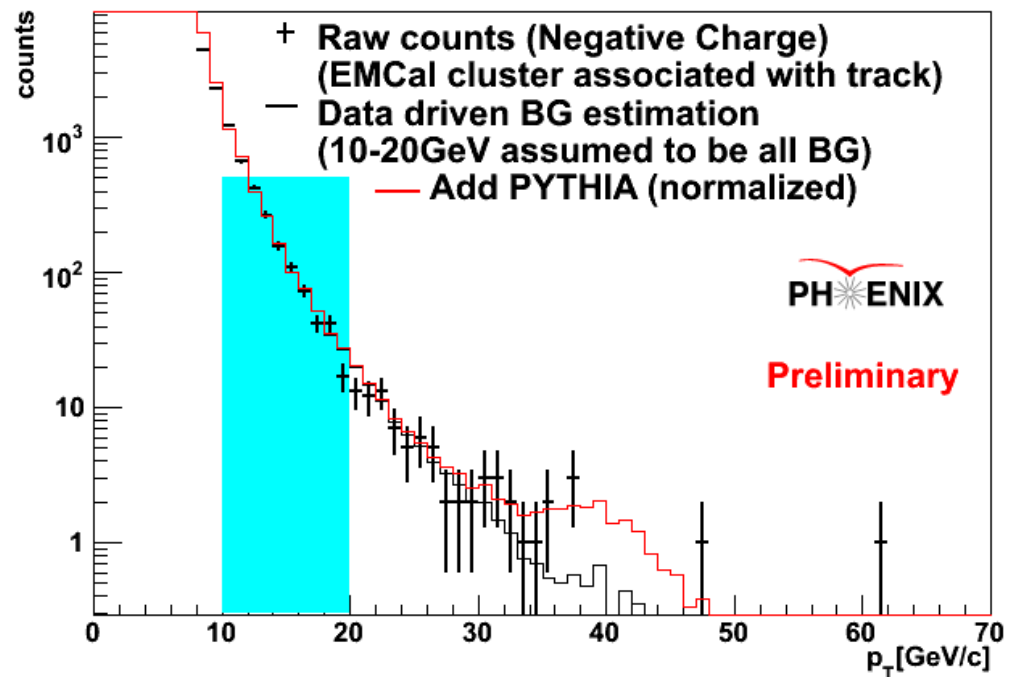
Positive

- Positive charged tracks matched with EM Calorimeter cluster
- Background estimated using 10-20 GeV/c region



Negative

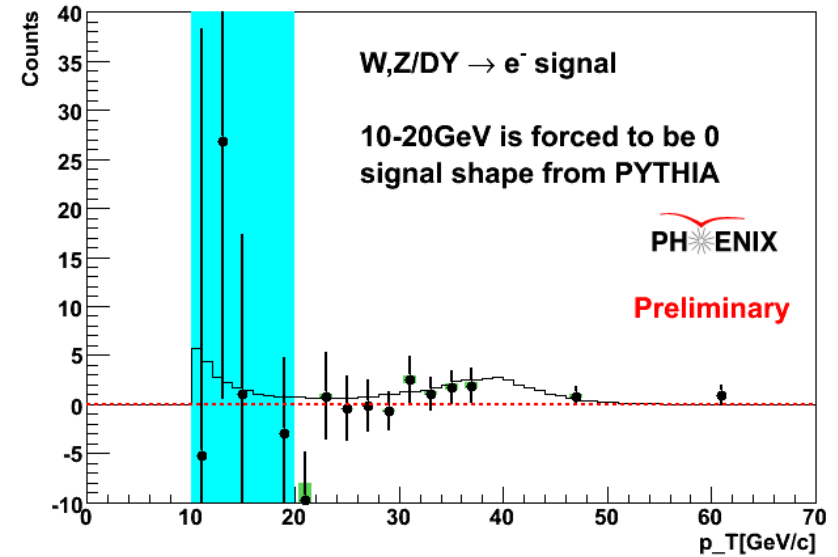
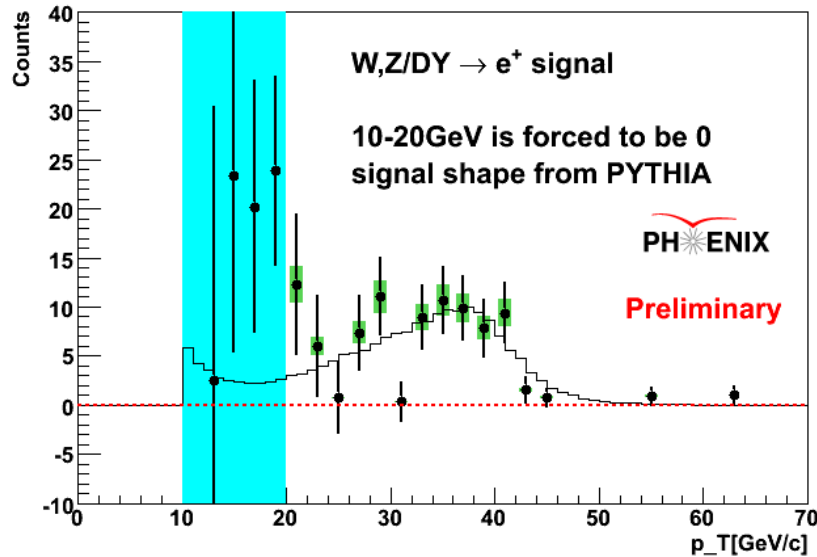
- Estimated 25% contamination from Z^0 (larger fraction because lower W^- statistics)



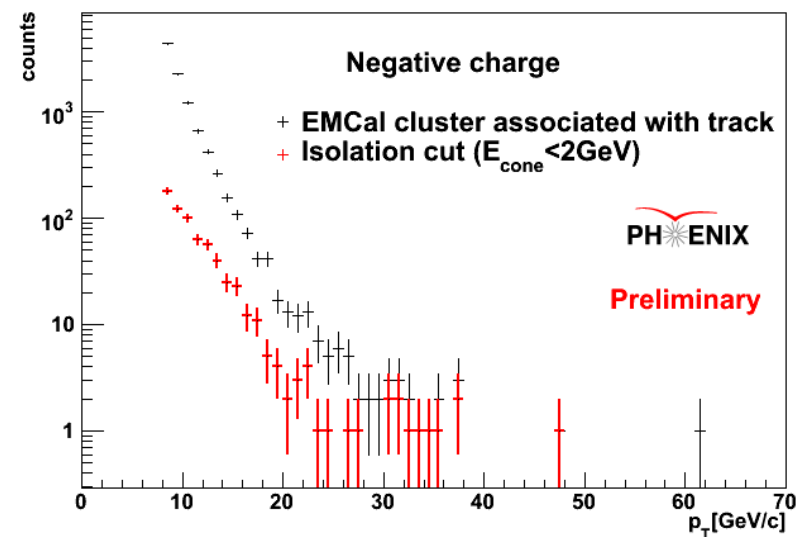
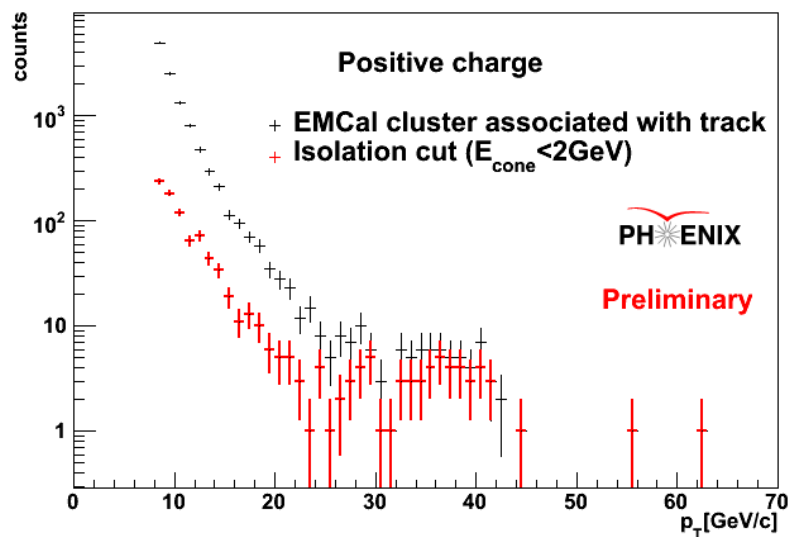
Background subtracted

+

-



Isolation cut



Event sample $30 < p_T < 50 \text{ GeV}/c$

From 9.28 pb^{-1} of data

| Sample | Raw counts | Background counts | Background subtracted | Isolation cut counts |
|----------|------------|-------------------|-----------------------|----------------------|
| Positive | 60 | 11.1 | 48.9 | 39 |
| Negative | 16 | 10.6 | 5.4 | 11 |
| Total | 76 | 21.7 | 54.3 | 50 |

Acceptance

- Acceptance calculation in progress
- Account for acceptance variation during run
- Acceptance factors:
 - Solid angle
 - ± 30 cm vertex cut
 - Trigger efficiency
 - Calorimeter hot/dead towers
 - Tracking efficiency

A_L measurement

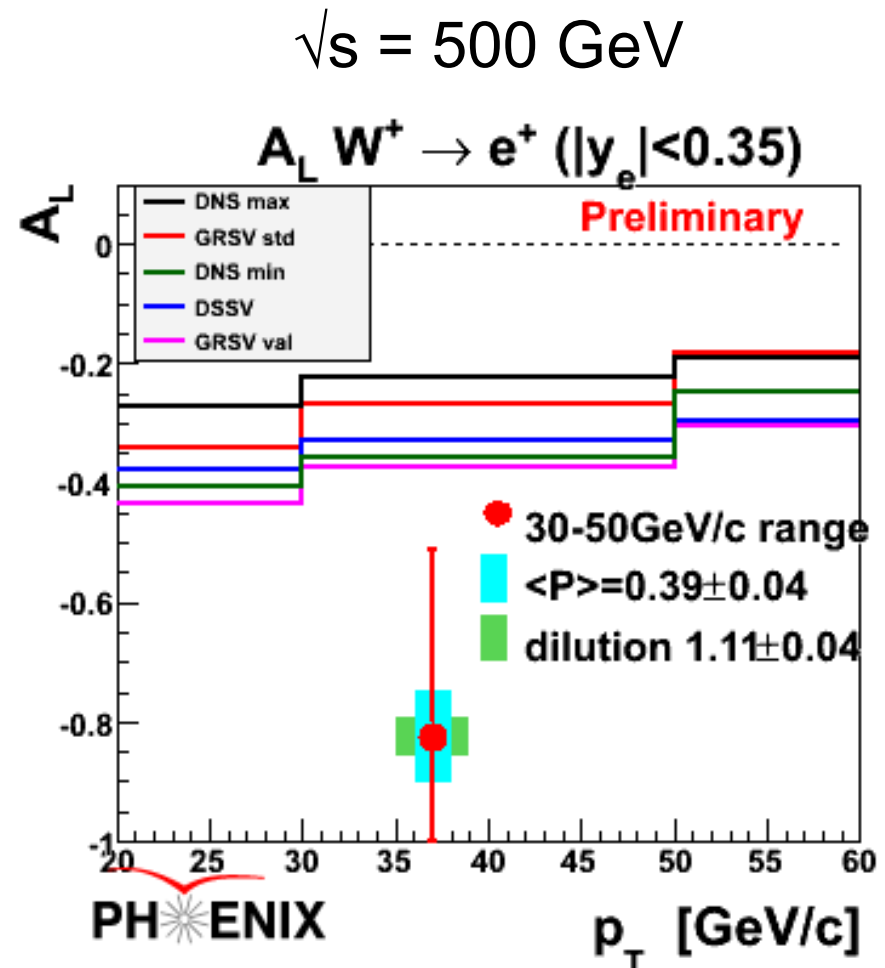
- First measurement with W^+ sample
- Raw asymmetry ε_L measured in background region small and error estimation consistent; 12-20 GeV gives

$$\varepsilon_L = +0.035 \pm 0.047$$

A_L for W^+ sample

- Average polarization 0.39 ± 0.04
- Correct polarization for dilution by Z and QCD backgrounds
- Raw asymmetry -0.29 ± 0.11 leads to

$$A_L^{W^+} = -0.83 \pm 0.31$$



Conclusion

- PHENIX has seen its first central arm W's
- Acceptance calculation and background estimates in progress
- First attempt to measure single spin asymmetry has detected a parity violating asymmetry leading to a preliminary value of

$$A_L^{W^+} = -0.83 \pm 0.31$$

The future

- This was a short exploratory run which has taught us a lot
- Future RHIC running at 500 GeV is expected to have higher polarization and longer running time
- The PHENIX detector is undergoing considerable upgrades to enable a program of measurements of W^\pm in the forward direction
- Talks at this conference cover forward upgrades, trigger (Vossen, Kempel, Sansour, Choi)